P2

44

Bell Aerospace Company DIVISION OF textron

BUFFALO, NEW YORK 14240 716-297-1000

CONTRACT NAS 9-12996

MONTHLY PROGRESS REPORT, SPACE SHUTTLE RCS ENGINE

PERIOD ENDING 17 AUGUST 1973

BELL MODEL 8701

REPORT NO. 8701-910013

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACECRAFT CENTER
HOUSTON, TEXAS

REFERENCE: DATA ITEM T-853-2

22 AUGUST 1973

APPROVED BY: M.L. CHAZEN
PROGRAM MANAGER/TECHNICAL DIRECTOR
RCS ENGINE PROGRAM

NASA TECHNICAL MONITOR: MR. NORMAN CHAFFEE

Bell Aerospace Company DIVISION OF textron

BUFFALO, NEW YORK 14240 716-297-1000

CONTRACT NAS 9-12996

MONTHLY PROGRESS REPORT, SPACE SHUTTLE RCS ENGINE

PERIOD ENDING 17 AUGUST 1973

BELL MODEL 8701

REPORT NO. 8701-910013

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACECRAFT CENTER
HOUSTON, TEXAS

REFERENCE: DATA ITEM T-853-2

22 AUGUST 1973

APPROVED BY: M.L. CHAZEN
PROGRAM MANAGER/TECHNICAL DIRECTOR
RCS ENGINE PROGRAM

NASA TECHNICAL MONITOR: MR. NORMAN CHAFFEE

I

TABLE OF CONTENTS

SECTION		PAGE
	Summary	ii
1.0	General	1
1.1	Program Objectives	1
1.2	Program Plan	4
1.3	Engine Description	4
2.0	Progress	4
2.1	Monthly Progress Report	4
2.2	Monthly Resources Report	4
3.0	Test	8
3.1	Engine S/N FT-2A	8
3.2	Engine S/N RDV-2B	8
4.0	Work to be Performed During the Next Report Period	20
4.1	Engine S/N FT-2A	20
4.2	Engine S/N RDV-2B-1	20

MONTHLY PROGRESS REPORT, SPACE SHUTTLE RCS ENGINE

PERIOD ENDING 17 AUGUST 1973

T-853-2

Summary

The design of the Space Shuttle RCS Engine has the primary objective of reusability with minimum servicing. The program has just completed its thirteenth month of operation.

Engine S/N FT-2A has successfully completed all ten environmental (salt water spray, sand and dust, vibration and humidity) and hot fire cycles with no change in engine performance (steady state or pulse mode).

Engine S/N RDV-2B has successfully completed Profiles A, B and C accumulating the following with no servicing:

2568 Firings

3732 seconds accumulated firing time

Included in the three profiles are two (helium saturated and unsaturated propellants) worst case missions (9-90 seconds firings + pulses accumulating 965 seconds firing time) and one maximum endurance test (600-second continuous firing).

During the next report period the following will be conducted:

Engine S/N FT-2A will complete a worst case mission and initiate random vibration.

Engine S/N RDV-2B will continue its multi-mission hot fire testing.

MONTHLY PROGRESS REPORT, SPACE SHUTTLE RCS ENGINE

PERIOD ENDING 17 AUGUST 1973

T-853-2

1.0 General

Bell Aerospace Company has evolved the design philosophy for the Space Shuttle RCS Engines. It is predicated on the need for long life with minimum servicing. Consequently, it includes; long life, compatible materials; injector/valve of the simplest type, free from contamination traps and having a high degree of visual inspectability; a chamber having large thermal margins to provide an engine insensitive to feed system anomalies and malfunction c ndi-tions. Specific impulse should be as high as possible comensurate with the reusability and servicing requirements and thermal margin. Table 1-1 shows the engine requirements and Table 1-2 shows the performance goals.

1.1 Program Objectives

The overall objective of this program is to firmly define the level of the current technology base and the area of N_2O_4/MMH RCS engines suitable for Space Shuttle application. This will be accomplished by a program of engine analyses, design, fabrication and test. The program will culminate in a comprehensive final report and delivery of engine hardware to NASA. Specific objectives of this program include:

1. Demonstration of the capability to extrapolate the current engine design experience to the RCS of the representative shuttle requirements having the required safety, reliability, performance, wide off limits operational capability and minimum servicing and maintenance requirements.

2. Demonstration of multiple reuse capability.

3. Identification of current design and technology deficiencies and critical areas for future effort.

4. Provide engine design and performance information to guide decisions in the mainstream vehicle program.

TABLE I-1. DESIGN REQUIREMENTS

Vacuum Steady State Thrust (F_{∞})	600 lbs.
Exhaust Nozzle Area Ratio (ϵ)	40
Steady State Chamber Pressure (Pc)	200 psia
Engine Steady State Mixture Ratio (O/F)	1.6
Propellants	
Oxidizer	N_2O_4(MIL-P-26539C MON-1
Fuel	MMH (MIL-P-27404A)
Pressurant	Helium
Propellant Feed Conditions	
Static Pressure	300 ± 6 psia
Dynamic Pressure	290 ± 10 psia
Temperature	75 ± 35°F
Valve Voltage	28 ± 4 VDC
Minimum Impulse Bit (Nominal Conditions)	30 ± 10 lb-sec
Maximum Pulse Frequency	5 cps
Maximum Single Firing	600 sec.
Maximum Firing Time per Mission	1000 sec.
Maximum Number Pulses per Mission	2000
Engine Life	100 missions 10 years 100,000 sec. 200,000 pulses
Stability	
High Frequency	Dynamically Stable - Recovery in 20 ms
Low Frequency	Oscillations - ±5%
Thrust Vector Alignment	0.5°
Maximum Outer Wall Temperature	800°F
Engine Environment	
Temperature	-20°F to +300°F
Launch/Reentry Temperature	2000°F at nozzle exit
(5 minutes)	1500°F at throat
Pressure	S/L to 10^{-13} torr.
Acceleration (twice/mission)	3.5g for one min.
Vibration (5 minutes in each axis/ mission)	*0.1g^2/hz(20-300 hz) 3db/octave (300-2000 hz
Shock	TBD
Rain (per mission)	0.5 in/hr for 0.5 hr.
Sand (per mission)	140 mesh-500 FPM (4 hr.
Salt Atmosphere (per mission)	Coastal areas at 75±20°F for 30 da.
Humidity (per mission)	0-100% RH for 30 da.
Leakage of Propellants or Combustion Gases	None

*Contract amended to change random vibration (one minute in each axis/ mission) and define sinusoidal vibration:

Random Vibration		Sinusoidal Vibration	
20 - 90 Hz	0.1g^2/Hz	5 - 23 Hz	1g
90 - 180 Hz	+12db/octave	23 - 40 Hz	0.036" D.A.
180 - 350 Hz	1.6 g^2/Hz		
350 - 2000 Hz	-6db/octave		

TABLE 1-2

PERFORMANCE GOALS

STEADY STATE VACUUM SPECIFIC IMPULSE ($I_{sp\infty}$)	295 SEC.
PULSE VACUUM SPECIFIC IMPULSE ($I_{sp\infty}$)	220 SEC (I_T = 30 LB-SEC)
ENGINE START TIME (0-90% P_c)	50 MS
ENGINE DECAY TIME (100-10% P_c)	50 MS
SPECIFIC IMPULSE SHIFT	MINIMUM
MIXTURE RATIO SHIFT	MINIMUM
OFF LIMITS OPERATION	CAPABILITY TO WITHSTAND

1.2 Program Plan

Bell Aerospace Company will conduct a program of analyses, design, fabrication, test, and documentation, of RCS engine to demonstrate the technology available for the Space Shuttle RCS Engine. The program consists of five phases as follows, based on contract modification 4C/5S.

Phase I	Analysis, Supporting Tests and Design
Phase II	Hardware Fabrication
Phase III	Engine Testing
Phase IV	Post Test Analysis and Design
Phase V	Engine Evaluation Hardware to be Submitted to NASA.

A summary of the program elements and their relationship to the program is shown in Figure I-1. The length of the program is 17 months.

1.3 Engine Description

The Bell flight type engine is a film cooled, insulated coated columbium alloy thrust chamber and nozzle extension, a direct acting torque motor bipropellant valve (See Figure I-2). Thermal protection of the engine valve is provided by a titanium stand off which is electron beam welded directly to the columbium injector. The injector is of a doublet configuration with fuel barrier and is designed so that oxidizer cannot get to the wall so as to provide a large thermal margin and high reliability. External insulation is accomplished by a low density Dynaflex blanket encased in foil and mechanically attached to the engine.

2.0 Progress

2.1 Monthly Progress Report

The twelfth monthly progress report (8701-910012) was submitted on 8/6/73. The required submittal date was 8/6/73.

2.2 Monthly Resources Report

The twelfth monthly resources report (8701-910027) was submitted on 8/6/73. The required submittal date was 8/9/73.

SPACE SHUTTLE RCS ENGINE PROGRAM

BASIS: CONTRACT MODIFICATION 4C/5S

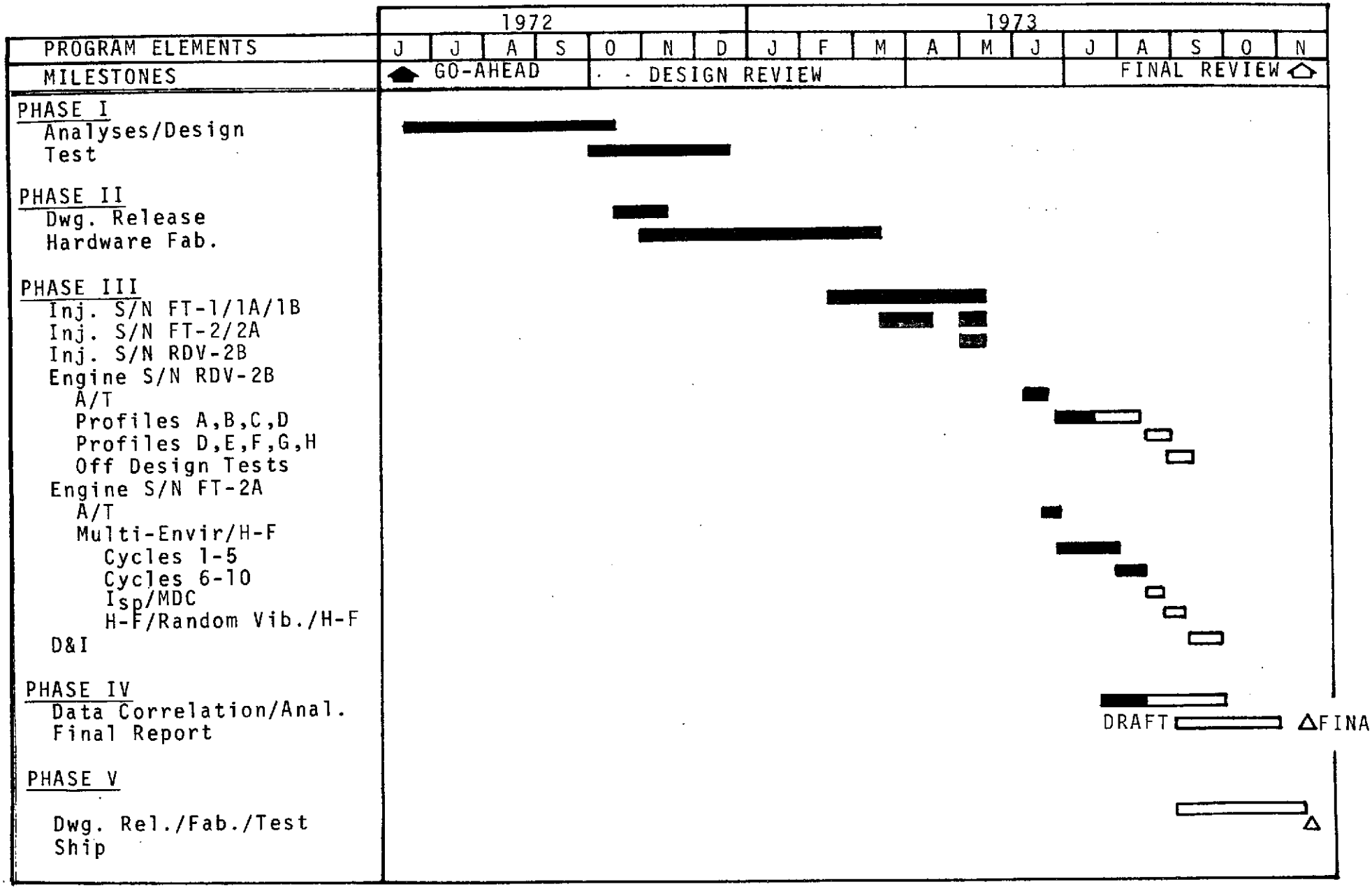

FIGURE 1-1

SPACE SHUTTLE RCS ENGINE - PROGRAM SCHEDULE

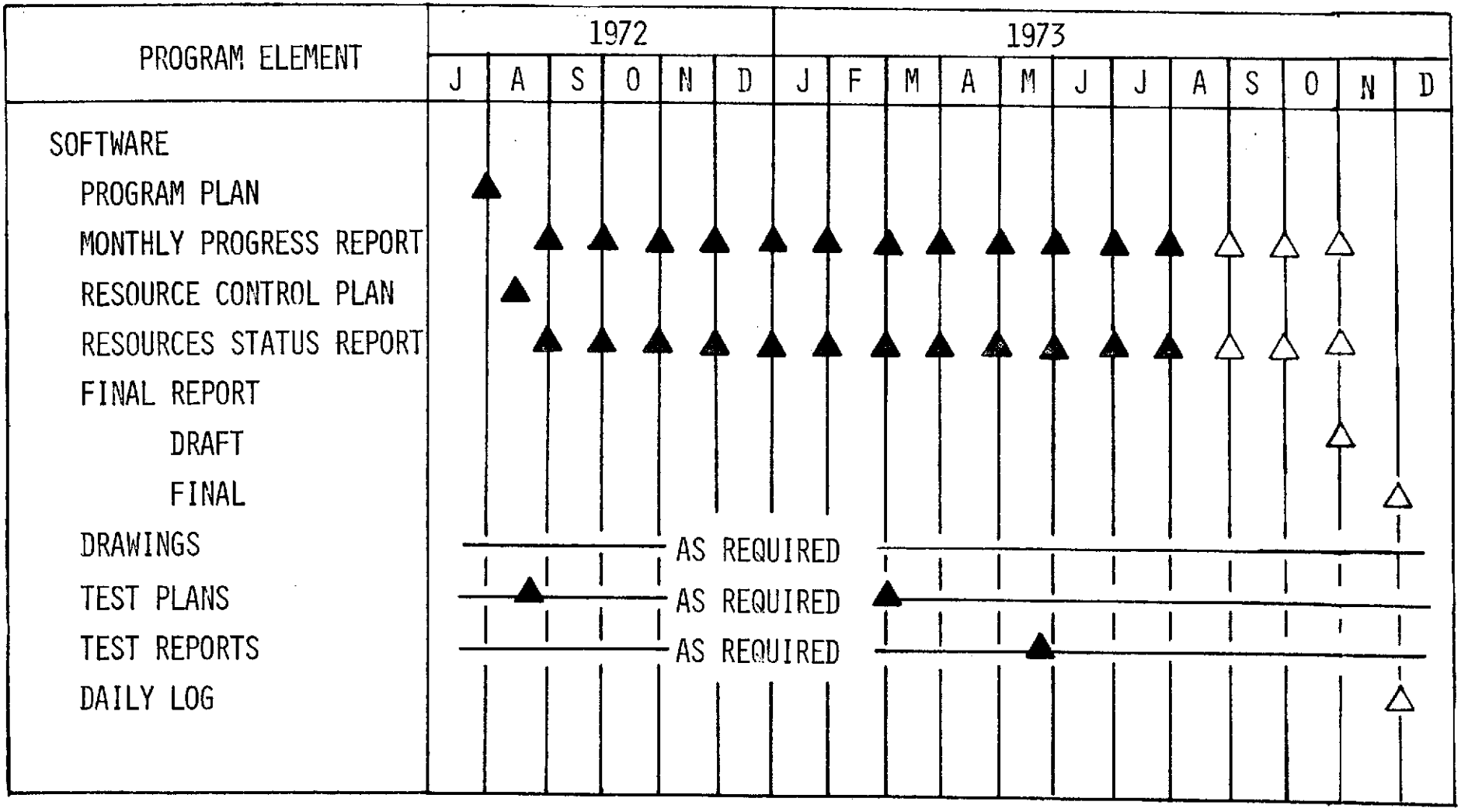

FIGURE 1-1

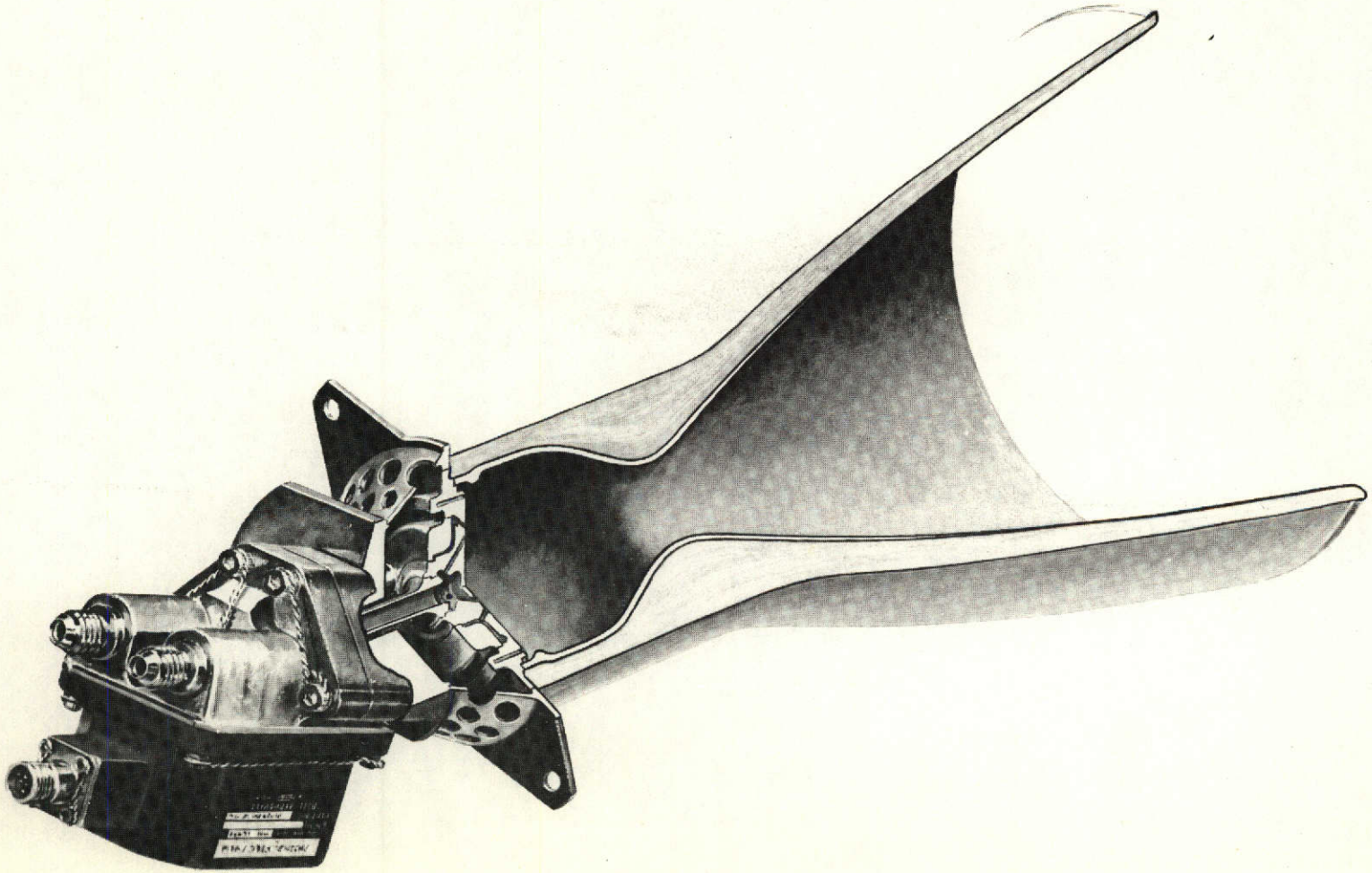

Figure I-2. 600 lb Thrust Engine

3.0 Test

3.1 Engine S/N FT-2A

Engine S/N FT-2A which is shown in Figure 3-1 successfully completed its ten multi-mission environmental/hot fire test program. Each cycle consisted of the following:

Cycle 1 & 10

a. Salt spray per MIL-STD-810B for 30 minutes with nozzle up at 45°.

b. Sand and dust for 4 hours with nozzle up.

c. Sinusoidal vibration for six minute sweep plus dwell time per each of three orthogonal axes.

d. Temperature and humidity for over seven hours over range of 40-160°F and 95% relative humidity.

e. Hot fire test - pulsing and steady state.

Cycle 2 - 9

a. Salt spray per MIL-STD-810B for 30 minutes with nozzle up at 45°F.

b. Sand and dust for 4 hours with nozzle up.

c. Sinusoidal vibration for six minute sweep plus dwell time in worst case axis (Z axis).

d. Temperature and humidity for over seven hours over range of 40-160°F and 95% relative himidity.

e. Hot fire test - pulsing and steady state.

In addition, Engine S/N FT-2A was subjected to a series of baseline pulse specific impulse tests after completion of the tenth cycle. In order to evaluate the impact of the ten multi-mission environmental/hot fire cycles, the program was conducted over an elapsed time of approximately two months. Table 3-1 shows the fire test data after each of the ten environmental cycles. No change in performance was noted (data within instrumentation accuracy).

3.2 Engine S/N RDV-2B

Engine S/N RDV-2B which is shown in Figure 3-2, completed its second month of the multi-mission hot fire test program accumulating the following:

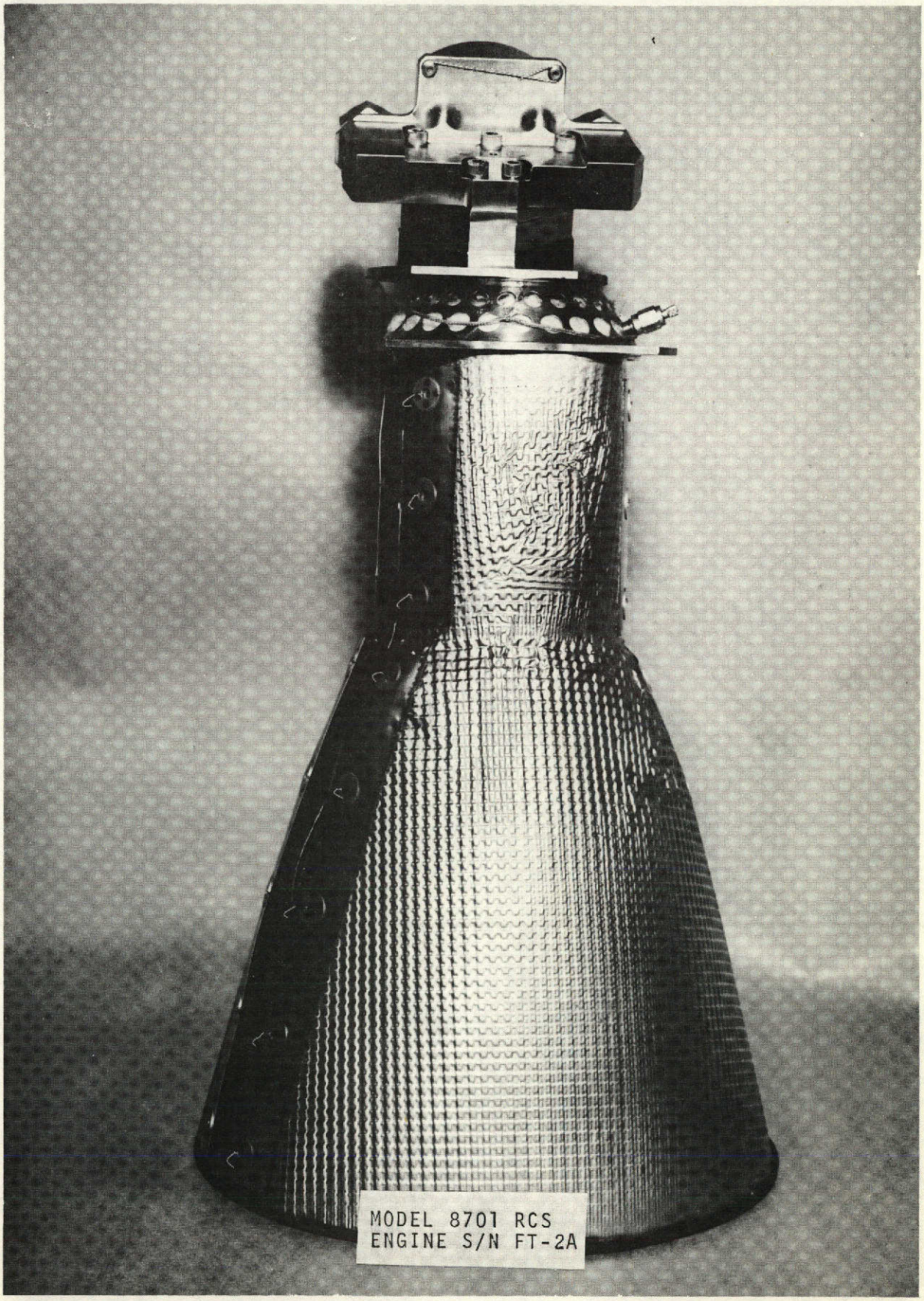

Figure 3-1

TABLE 3-1

TEST SUMMARY-ENGINE S/N FT-2A POST ENVIRONMENTAL CYCLES
e = 40

DATE	TEST NO.	I_T (LB-SEC) (50 MS PUL)	σ (LB-SEC)	O/F	P_c (PSIA)	C* FT/SEC	$I_{sp\infty}$ (SEC)	Remarks
6/20/73	B-1-780			1.60	198.7	5283	296.5	Baseline test prior to environmental testing.
6/21/73	B-1-783	21.3	0.7					" "
6/21/73	B-1-784	20.0	0.4					" "
7/11/73	B-1-809	22.8	0.3					Post Cycle #1.
7/11/73	B-1-810			1.64	199.2	5254	296.6	Post Cycle #1.
7/19/73	B-1-825	21.1	0.4					Post Cycle #2.
7/19/73	B-1-826			1.58	201.4	5281	296.0	Post Cycle #2.
7/25/73	B-1-827	23.6	0.3					Post Cycle #3.
7/25/73	B-1-828			1.64	199.2	5274	295.6	"
7/27/73	B-1-829	23.3	0.4					Post Cycle #4.
7/27/73	B-1-830			1.58	198.8	5288	295.6	"
7/30/73	B-1-831	24.2	0.3					Post Cycle #5.
7/30/73	B-1-832			1.64	196.9	5270	295.5	"

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

TABLE 3-1 (Cont'd)

DATE DATE	TEST NO.	I_T (LB-SEC)(50 MS PULSES EPW)	(LB-SEC)	O/F	(PSIA)	FT/SEC	$I_{sp\infty}$ (SEC)	Remarks
7/31/73	B-1-833	23.5	0.3					Post Cycle #6.
7/31/73	B-1-834			1.60	198.1	5302	295.7	"
8/3/73	B-1-835	23.2	0.6					Post Cycle #7.
8/3/73	B-1-836			1.61	196.8	5279	295.2	"
8/8/73	B-1-839	23.8	0.3					Post Cycle #8.
8/8/73	B-1-840			1.61	198.5	5268	295.7	"
8/13/73	B-1-846	23.5	0.4					Post Cycle #9.
8/13/73	B-1-847			1.63	193.3	5272	294.1	"
8/15/73	B-1-849	23.8	0.3					Post Cycle #10.
8/15/73	B-1-850			1.58	193.9	5293	294.9	"

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

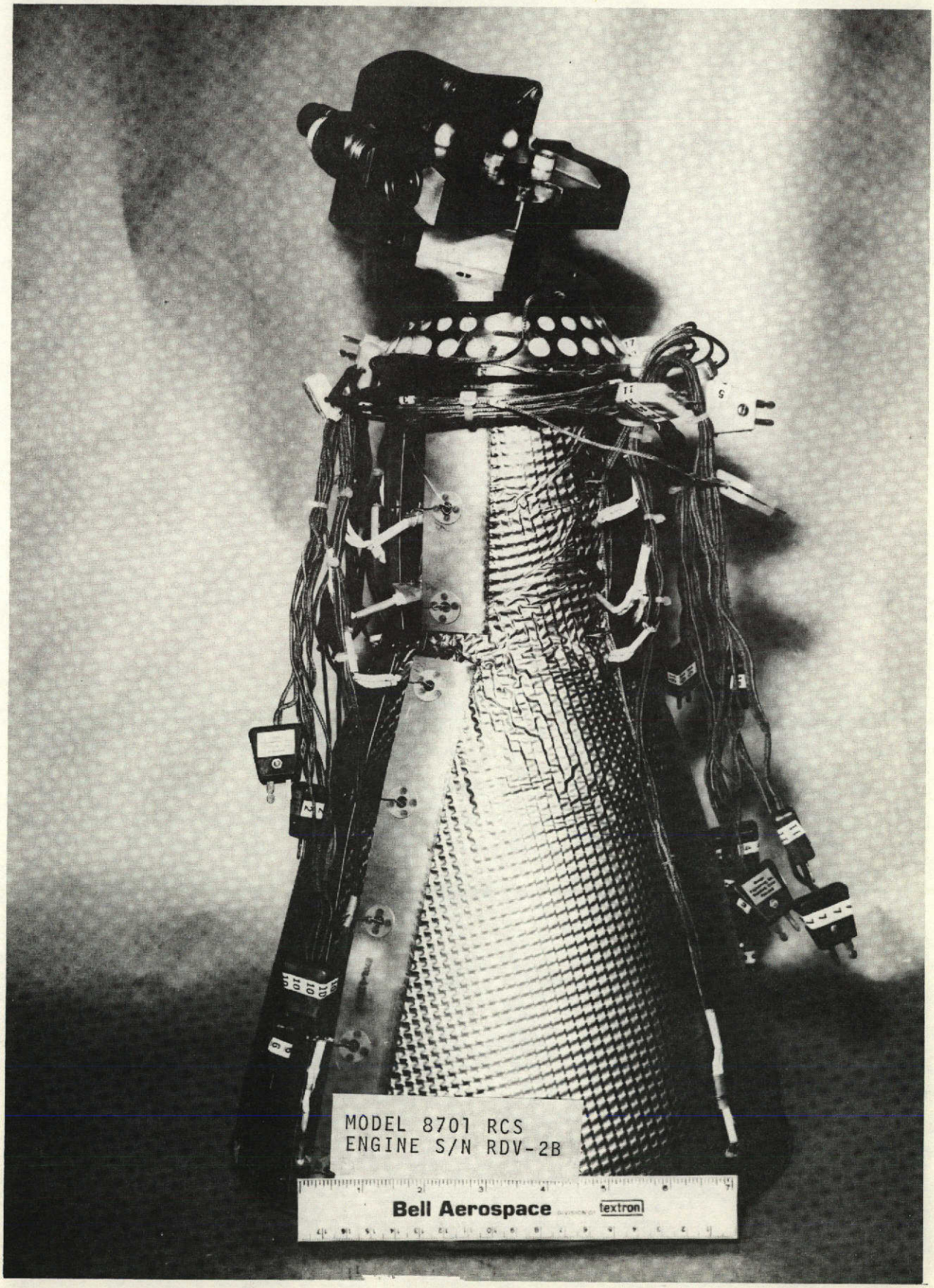

Figure 3-2

Total burns - 2568

Total Firing Time - 3732 seconds

The program to date has completed the following:

Profile A - Thermal Duty Cycle (steady state firings + pulses)
Pulse Specific Impulse Tests
Worst Case Mission Duty Cycle (965 seconds on-time and 120 Firings including 9-90 second firings + pulses).

Profile C - Same as Profile A except helium saturated propellants utilized.

Profile B - Endurance Test (600-seconds).

Profile D - Pulse Specific Impulse Tests (in process)
Steady State Performance Tests (to be accomplished).

A summary of the Profile A test data is shown in Tables 3-2 (Thermal Duty Cycle), 3-3 (Pulse $I_{sp\infty}$) and 3-4 (Worst Case MDC). The performance data (steady state) of the Thermal Duty Cycle indicates an average measured vacuum specific impulse of 294.3 seconds (ε = 40) compared to the baseline acceptance test performance of 295.3 seconds (ε = 40). The impulse bit performance for 50 ms pulses at 1 cps and 2 cps indicates no significant difference (IT = 24.2 lb-sec) but the 5 cps data indicates a higher impulse bit (26 lb-sec). The results of the pulse specific impulse tests indicate that there is essentially no difference in pulse performance between 1 cps and 0.2 cps. However, there is a substantial increase (12.5%) at 5 cps. The data at 1 cps indicates a vacuum pulse specific impulse of 200 seconds while the data at 5 cps indicates 253.5 seconds. The worst case mission duty cycle indicated a steady state average vacuum specific impulse of 294.7 seconds compared to the thermal duty cycle value of 294.3 seconds and the acceptance test value of 295.3 seconds.

The engine was then subjected to Profile C, which is identical to Profile A except helium saturated propellants are utilized. A summary of the test data of Profile C is shown in Tables 3-5 (Thermal Duty Cycle), 3-6 (Pulse $I_{sp\infty}$) and 3-7 (Worst Case MDC). The steady state performance of the thermal duty cycle with helium saturated propellants indicates a vacuum specific impulse of 294.8 seconds which is the same as Profile A. The impulse bit performance for 50 ms pulses at 1 cps and 2 cps indicates no significant difference but the 5 cps data indicates higher impulse bit. The results of

TABLE 3-2

PROFILE A

THERMAL DUTY CYCLE TEST SUMMARY

ENGINE S/N RDV-2B
e = 40

Test No. B-1-785-	O/F	P_c (psia)	C* (Ft/Sec)	I_{spoo} (Sec)	Pulse EPW (ms)	Pulse Freq. (cps)	I_T (Lb-Sec)	σ_{I_T} (Lb-Sec)
A	1.57	195.9	5254	294.4				
B	1.57	195.8	5255	293.7				
C	1.57	196.1	5266	294.3				
D	1.56	196.4	5267	294.1				
E					50	5	QUESTIONABLE DATA	
F	1.56	196.5	5277	294.6				
G					50	2	24.1	0.3
H	1.56	196.8	5278	294.5				
I					50	1	24.4	0.3
J	1.56	197.0	5283	294.5				
K					50	5	26.0	1.3
L	1.56	196.8	5275	293.7				
M					50	2	23.9	0.3
N	1.56	197.5	5292	294.7				
O					50	1	24.3	0.3
P	1.56	197.5	5298	294.9				

NOTE: I_{spoo} and I_T are based on measured thrust.

TABLE 3-3

PROFILE A

PULSE PERFORMANCE CHARACTERIZATION SERIES

TEST SUMMARY

ENGINE S/N RDV-2B

e = 40

TEST NO.	Pulse Freq. (CPS)	Pulse EPW (MS)	I_T (LB-SEC)	σ (LB-SEC)	Pulse $I_{sp\infty}$ (SEC)
B-1-786	1	50	26.8	0.5	QUESTIONABLE FLOW DATA
B-1-787	1	50	26.7	0.2	200.1
B-1-788	1	50	26.8	0.2	200.9
B-1-789	5	50	31.6	0.8	253.5
B-1-790	5	50	31.6	0.7	253.7
B-1-791	0.2	50	24.6	0.4	198.4
B-1-792	1	91	50.9	0.3	238.4
B-1-793	1	92	50.7	0.3	
B-1-794	1	170	96.1	1.8	256.7
B-1-795	1	170	94.7	0.4	
B-1-796	1	36	10.3	4.8	126.1
B-1-797	1	36	9.9	4.7	
B-1-798	1	28	2.5	0.15	91.7
B-1-799	1	28	2.6	0.13	

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

TABLE 3-4 - PROFILE A

WORST CASE MISSION DUTY CYCLE TEST SUMMARY

ENGINE S/N RDV-2B-1
e = 35

Test B-1-807 Burn No.	Duration (Sec)	O/F	P_c (psia)	C* (Ft/Sec)	$I_{sp\infty}$ (Sec)	$I_{sp\infty}$ (e = 40) (Sec)	$T_{Throat(Max)}$ °F
0-P	10-50 MS PULSES (1 CPS)						
1	103.4	1.61	196.9	5269	292.4	295.6	2159
1-P	10-50 MS PULSES (1 CPS)						
2	95.4	1.60	195.4	5244	291.5	294.7	2250
2-P	10-90 MS PULSES (1 CPS)						
3	97.8	1.59	197.1	5299	290.6	293.8	1937
3-P	10-50 MS PULSES (1 CPS)						
4	92.5	1.59	196.5	5283	289.9	293.1	1945
4-P	10-170 MS PULSES (1 CPS)						
5	99.8	1.60	196.7	5286	289.9	293.1	1951
5-P	10-50 MS PULSES (1 CPS)						
6	99.9	1.58	197.0	5281	292.7	295.9	1859
6-P	10-90 MS PULSES (1 CPS)						
7	100.3	1.61	194.3	5288	291.8	295.0	2235
7-P	10-50 MS PULSES (1 CPS)						
8	95.0	1.60	195.7	5281	293.4	296.6	1821
8-P	10-170 MS PULSES (1 CPS)						
9	94.9	1.60	192.3	5287	291.5	294.7	1909
9-P	10-50 MS PULSES (1 CPS)						
10	81.2	1.60	192.9	5303	291.5	294.7	1873

NOTE: $I_{sp\infty}$ is based on measured thrust.

TABLE 3-5 - PROFILE C

THERMAL DUTY CYCLE TEST SUMMARY

ENGINE RDV-2B-1 - e = 35/1

Test No. B1-811-	O/F	P_c PSIA	C* (FPS)	$I_{sp\infty}$ (SEC)	$I_{sp\infty}$ e = 40 (SEC)	PULSE EPW (MS)	PULSE FREQ. (CPS)	I_T (LB-SEC)	σ (LB-SEC)
A	1.71	199.4	5223	291.3	294.6				
B	1.72	199.1	5207	291.3	294.6				
C	1.71	199.6	5228	291.5	294.8				
D	1.71	199.9	5239	291.5	294.8				
E						51	5	29.33	1.2
F	1.71	200.3	5247	291.1	294.4				
G						51	2	26.87	0.4
H	1.72	200.6	5251	291.7	295.0				
I						51	1	26.78	0.3
J	1.71	200.7	5258	291.2	294.5				
K						50	5	27.64	1.5
L	1.71	201.0	5276	291.6	294.9				
M						50	2	23.52	0.5
N	1.70	201.2	5289	292.0	295.3				
O						51	1	24.02	0.9
P	1.69	201.0	5291	292.1	295.4				

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

TABLE 3-6 - PROFILE "C"

PULSE PERFORMANCE CHARACTERIZATION SERIES

TEST SUMMARY - ENGINE RDV-2B-1 - ϵ = 35/1

Test No.	Pulse Freq. (CPS)	Pulse EPW (MS)	I_T (LB-SEC)	σ (LB-SEC)	Pulse $I_{sp\infty}$ (SEC)	$I_{sp\infty}$ ϵ = 40 (SEC)
B-1-812	1	51	32.8	3.2	208.5	210.8
813	1	51	30.8	.4	211.1	213.5
814	5	51	30.0	4.0	221.4	223.9
815	0.2	51	29.4	.2	198.1	200.3
816	1	92	53.9	.3	233.7	236.3
817	1	173	100.3	.3	251.4	254.2
818	1	36	19.3	.2	177.6	179.6
819	1	28	11.1	1.6	139.1	140.7
820	5	51	30.0	.4	224.4	226.9
821	1	92	52.7	.2	255.7	228.2
822	1	172	99.3	3.4	244.5	247.3
823	1	36	20.0	.2	178.2	180.2
824	1	27	6.7	1.1	115.5	116.8

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

TABLE 3-7 - PROFILE "C"

WORST CASE MISSION DUTY CYCLE TEST SUMMARY

ENGINE RDV-2B-2 - ϵ = 33/1

TEST NO. B-1-845 BURN NO.	DURATION (SEC)	O/F	P_c (PSIA)	C* (FT/SEC)	$I_{sp\infty}$ (SEC)	$I_{sp\infty}$ (ϵ=40/1) (SEC)	$T_{THROAT(MAX)}$ (^oF)
0-P	10-50MS PULSES						
1	95.2	1.62	197.2	5275	291.3	294.7	1898
1-P	10-50MS PULSES						
2	65.2	1.63	198.7	5262	293.6	297.1	1940
2-P	10-90MS PULSES						
3	95.2	1.63	199.9	5270	291.2	294.6	1957
3-P	10-50MS PULSES						
4	90.5	1.61	202.0	5280	290.7	294.1	
4-P	10-170MS PULSES						
5	89.6	1.56	199.8	5299	291.6	295.0	1930
5-P	10-50MS PULSES						
6	89.7	1.61	199.5	5282	292.3	295.8	1976
6-P	10-90MS PULSES						
7	89.9	1.61	200.8	5283	292.9	296.4	2006
7-P	10-50MS PULSES						
8	90.2	1.57	204.7	5304	291.0	294.4	1963
8-P	10-170 MS PULSES						
9	90.2	1.61	203.8	5295	293.2	296.7	2005
9-P	10-50 MS PULSES						
10	89.7	1.61	205.4	5298	292.8	296.3	2024
10-P	10-90 MS PULSES						

NOTE: $I_{sp\infty}$ and I_T are based on measured thrust.

the pulse specific impulse tests indicate that there is an increase in vacuum specific impulse with increasing frequency with helium saturated propellants (200.3 seconds at 0.2 cps, 212.2 seconds at 1 cps and 225.4 seconds at 5 cps). In addition, there is an increase in pulse specific impulse at 1 cps at low pulse widths (27, 36 and 50 ms) with helium saturated propellants compared to non-saturated propellants. There appears to be no change at 90 ms and 170 ms pulse widths between saturated and non-saturated propellants. The engine was then prepared for the worst case mission duty cycle. In preparation for this mission the engine nozzle was accidently damaged. The nozzle was then cut back to $\epsilon = 33$ from $\epsilon = 35$ and the engine designated S/N RDV-2B-2. The engine then successfully completed the worst case mission. A summary of the worst case mission data is shown in Table 3-7. The average specific impulse ($\epsilon = 40$) was 295.5 seconds which is essentially the same as Profile A.

The engine then successfully completed the maximum-endurance test which is a 600-seconds continuous firing. The results indicate an average vacuum specific impulse of 294.7 seconds ($\epsilon = 40$) which is similar to previous data for this engine. A summary of the 600-second test data is shown in Table 3-8.

4.0 Work to be Performed During the Next Report Period

4.1 Engine S/N FT-2A

Complete the Worst Case Mission Duty Cycle and initiate random vibration.

4.2 Engine S/N RDV-2B-2

Complete Profile D (pulse specific impulse and steady state tests over temperature range of 40-110°F).

TABLE 3-8 - PROFILE B

ENDURANCE TEST SUMMARY

ENGINE S/N RDV-2B-2

ϵ = 33

DURATION OF TEST (B-1-848) - 600 SEC.

Data Point (Sec.)	O/F	P_c (PSIA)	C* (FT/SEC)	$I_{sp\infty}$ (SEC)	$I_{sp\infty}$ ϵ = 40 (SEC)	T_{THROAT} (MAX) (^oF)
4.5	1.59	194.3	5290	290.7	294.1	1097
10	1.59	194.3	5285	290.8	294.2	1645
30	1.59	194.2	5283	291.2	294.6	2058
60	1.59	194.1	5281	291.2	294.6	2180
120	1.59	193.7	5275	291.4	294.8	2225
180	1.59	193.6	5278	291.5	294.9	2228
240	1.59	193.5	5282	291.6	295.0	2198
300	1.59	193.3	5282	291.5	294.9	2219
360	1.59	193.1	5283	291.5	294.9	2203
420	1.59	193.1	5287	291.6	295.0	2193
480	1.59	192.8	5286	291.6	295.0	2182
540	1.59	192.5	5284	291.4	294.8	2173
599.4	1.59	192.4	5287	291.5	294.9	2162

NOTE: $I_{sp\infty}$ is based on measured thrust.